Massachusetts Department of Fish and Game

In-Lieu Fee Program

Eelgrass Restoration Project (IL01) 2021 Annual Report

Implemented by the Division of Marine Fisheries

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Submitted to

The Massachusetts In Lieu Fee Program

Administered by the Department of Fish and Game

Dan McKiernan, Director

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Project Overview

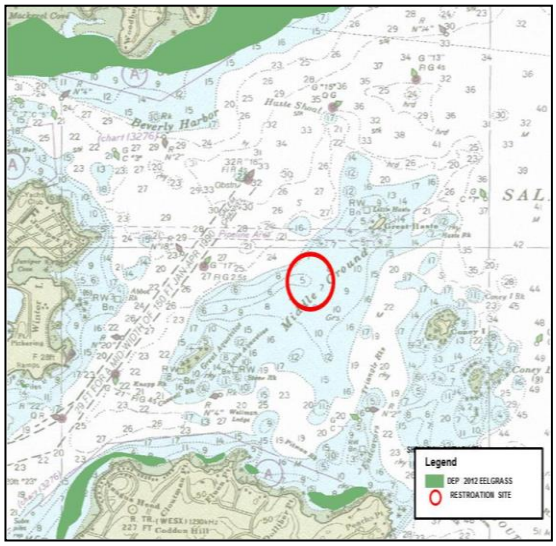

Figure 1. Middle Ground eelgrass restoration site in Salem Sound

The Massachusetts In-Lieu Fee Program (ILFP) funded The Division of Marine Fisheries (DMF) to restore and monitor ½ acre (2,023.4 m^2) of eelgrass in the North sub-area of the Coastal Service Area under the Corps General Permit number NAE-2017-00754. This report is for the calendar year 2021, the fifth year of the project and the third and fourth years of monitoring of planted plots.

Based on site selection results, DMF chose Middle Ground in Salem Sound to plant two ¼ acre (1,011.7 m^2) sets of three transects in 2017 (Figure 1 and 2). To mitigate for seasonal effects (storms, algae blooms, crabs), the restoration effort was split over two seasons, the West ¼ acre set (MGW) was planted in April and May 2017, while the East ¼ acre set (MGE) was planted in the end of August and September 2017 (Table 1). An additional, ¼ acre set (MGS) was planted directly South of MGW in May of 2018 after poor success was recorded at MGE. One-month monitoring of MGS was completed in June of 2018, showing survival of 99% of the planting units; a survival rate exceeding that observed at both MGW and MGE sets in 2017 (Frew at al. 2017, Appendix A). Additionally, 5 plots missing from MGW were replaced in May 2018, serving to augment the MGW set. This report focuses on monitoring completed in 2021 for planted plots at MGW and MGS. 2021 marks the the fourth year of monitoring of planted plots at MGW and MGE and the third year of monitoring at MGS.

In July 2021, monitoring was conducted at MGW for the thirteen plots planted in 2017 and for the five supplementary plots planted in 2018 (Table 2). Three year post-planting monitoring was conducted at MGS (Tables 1 & 2). Monitoring was not conducted at the "abandoned" set at MGE. Methods and results of the monitoring are detailed below.

Methods

Detailed planting methods are outlined in the Eelgrass Restoration Project Proposal and the previous annual reports. In July 2021, divers monitored transplant and reference sites, including the originally planted MGW and the replacement set at MGS (Table 2).

Restored sites

In 2021, divers again used Stage 2 monitoring where individual discs (planting units or PUs) are no longer counted as they are indistinguishable. Instead, divers counted the number of $1m^2$ squares within each plot (one square contained the original PUs that had coalesced). The squares then become the new measure of persistence, expansion or decline. Divers measured the length and width of one square within each of the 18 plots to quantify expansion, and measured plant morphometrics (shoot density, canopy

height, and percent cover) in a 1 m^2 area at three randomly chosen places within each of the 18 plots. Finally, divers made general observations and took video and still pictures.

Reference sites

Three reference, natural eelgrass meadows are monitored each year to obtain a mean reference value for comparison with values measured at the the restoration site. Divers monitored all three reference beds in July 2021 (West Beach, Peachs Point, and Aquavitae) (Table 2) using methods detailed in the Project Proposal and the previous annual reports to obtain a mean reference value for all metrics measured at the transplanted sites (shoot density, canopy height, and percent cover). All three reference sites will continue to be monitored once annually during the peak growing season (July) for comparison with restored sites.

Results

Transplant Sites

Middle Ground West (MGW)

In July 2021, four years post-planting at MGW, 75% of the planted squares persisted and were growing and expanding (Figure 3).

At the thirteen originally planted plots, 73% of the planted squares persisted with increased morphometrics and an expansion of area (Figure 3). Shoot density of vegetated squares increased by 44% from 2020 (ANOVA, $F_{1,56}$ = 6.5, P = 0.01; Figures 4&5; Table 3). Canopy height of vegetated squares increased by 22% from 2020 (ANOVA, $F_{1,56}$ = 7.4, P = 0.01; Figures 6&7; Table 3). Percent cover of vegetated squares did not differ statistically from 2020 (ANOVA, $F_{1,56}$ = 1.6, P = 0.21; Figures 8&9; Table 3). The area of the vegetated squares (m^2: 16.8 $\pm$ 2.7) increased by 126% from 2020 (ANOVA, $F_{1,19}$ = 7.6, P = 0.01; Figures 10&11; Table 3).

At the five supplementary plots, 80% of the planted squares persisted with increased morphometrics and an expansion of area (Figure 3). Shoot density of vegetated squares increased by 72% from 2020 (ANOVA, $F_{1,22}$ = 9.4, P < 0.01; Figures 4&5; Table 3). Canopy height of vegetated squares increased by 37% from 2020 (ANOVA, $F_{1,22}$ = 21.4, P < 0.01; Figures 6&7; Table 3). Percent cover of vegetated squares increased by 18% from 2020 (ANOVA, $F_{1,22}$ = 4.4, P = 0.048; Figures 8&9; Table 3). The area of the vegetated squares (m^2: 14.3 $\pm$ 3.8) increased by 495% from 2020 (ANOVA, $F_{1,8}$ = 9.8, P = 0.01; Figures 10&11; Table 3).

Middle Ground South (MGS)

In July 2021, three years post-planting at MGS, 67% of the planted squares persisted with increased morphometrics and an expansion of area (Figure 3). Shoot density of the vegetated squares increased by 118% from 2020 (ANOVA, $F_{1,83}$ = 34.4, P < 0.01; Figures 4&5; Table 3). Canopy height of vegetated squares increased by 38% from 2020 (ANOVA, $F_{1,83}$ = 10.9, P < 0.01; Figures 6&7; Table 3). Percent cover of vegetated squares increased by 40% from 2020 (ANOVA, $F_{1,83}$ = 8.2, P < 0.01; Figures 8&9; Table 3). The area of the vegetated squares(m^2: 8.2 ±2.1) increased by 228% from 2020 (ANOVA, $F_{1,31}$ = 5.3, P = 0.03; Figures 10&11; Table 3).

Middle Ground East (MGE)

This site was not sampled in 2021. Monitoring at MGE is planned during the peak growing season (July) of 2022 and 2023.

Reference Sites

The mean shoot density and percent cover declined at one reference site (Peachs Point), increased at another (Aquavitae), and remained stable at the third (West Beach). Canopy height did not differ from 2020 at two reference sites but declined at one of the reference sites (Peachs Point). In 2021, eelgrass metrics at the transplant sites fell within the range of values observed at the reference sites.

Peachs Point

Shoot density at Peachs Point declined by 58% from 2020 (ANOVA, $F_{1,22} = 6.1$, $P = 0.02$; Figure 4; Table 3). Canopy height decreased by 31% from 2020 (ANOVA, $F_{1,22} = 9.6$, $P = 0.01$; Figure 6; Table 3). Percent cover decreased by 55% from 2020 (ANOVA, $F_{1,22} = 5.7$, $P = 0.03$; Figure 8; Table 3).

West Beach

Shoot density at West Beach did not differ from 2020 (ANOVA, $F_{1,22} = 1.8$, $P = 0.2$; Figure 4; Table 3). Canopy height did not differ from 2020 (ANOVA, $F_{1,22} = 0.4$, $P = 0.56$; Figure 6; Table 3). Percent cover also did not differ from 2020 (ANOVA, $F_{1,22} = 0.9$, $P = 0.36$; Figure 8; Table 3).

Aquavitae

Shoot density at Aquavitae increased by 215% from 2020 (ANOVA, $F_{1,22} = 15.7$, $P < 0.01$; Figure 4; Table 3). Canopy did not differ from 2020 (ANOVA, $F_{1,22} = 0.2$, $P = 0.67$; Figure 6; Table 3). Percent cover increased by 77% from 2020 (Kruskal-Wallis rank sum test, $\chi^2_1 = 9.4$, $P < 0.01$; Figure 8; Table 3).

Requirements and Credit Release

Success Criteria (performance standards):

The goal of the project is the restoration of ½ acre of eelgrass after five years. Success is determined by the persistance and expansion of the planted eelgrass over five years. Because we planted a replacement set at MGS, that set will have had four years of monitoring by 2022. Therefore, we request an extension of one season of monitoring into 2023. The final report would be completed in 2023, which would allow for five complete years of monitoring at all planted plots.

Current plant metrics for the two ¼ acres of eelgrass planted at MGW and MGS are on the expected restoration trajectory (Figure 4). That is, they have continued to show eelgrass survival greater than 50% (73% MGW, 80% MGW supplementary and 67% MGS), and an annual increase in eelgrass density or eelgrass area overall.

In our 2020 report, we submitted a credit release request to the Corps for release of 20% of the credits due upon successful completion of the 2019 and 2020 monitoring at MGW and MGS. The Corps chose to release 20% of the credits for the annual monitoring in 2019 and 2020. So far, we have received 75% of the ILF credits to date, equivalent to 0.375 wetland mitigation credits.

At this time, we request the release of an additional 10% of credits for 2021 monitoring to include the fourth year of monitoring for MGW and the third year of monitoring for MGS.

Summary and Conclusions

MA DMF has successfully completed the 2021 seasonal monitoring of transplanted sites at the Middle Ground ILF restoration site in Salem Sound. In 2021, all transplant sites increased in morphometrics and expanded in area from the previous year. We plan to monitor the transplant sites again in July 2022 and July 2023. The final monitoring in 2023 will include diver surveys and acoustic mapping to document the full restoration area. A final report will be submitted in 2023.

CY2021 Budget Update

A budget update for Calendar year 2021 is provided below. Project expenses for 2021 amounted to $6,988 and the cumulative expenditures from 2017-2021 are $173,719. The balance of the approved budget for the project is $88,373. DFM will continue to monitor the restoration areas in Salem Sound in 2022 and 2023.

Salem Sound Eelgrass Restoration - Financial Update, Calendar Year (CY) 2017 – December 31, 2021

ILFP PROJECT BUDGET		EXPENDITURES						BALANCE
Line Item	**Approved Budget**	**CY 2017**	**CY 2018**	**CY 2019**	**CY 2020**	**CY 2021**	**Total CY 2017-2021**	**as of 12/31/2021**
SCUBA Air fills & Equipment	$11,556	$367.50	$2,443.00	$1,034.00	$90.00	$973.00	$4,907.50	$6,648.50
Field Supplies	$3,200	$552.80	$476.00	$1,339.00	$497.04	$386.00	$3,250.84	($50.84)
Licor Sensors	$560	$912.76	$0.00	$0.00	$0.00	$0.00	$912.76	($352.76)
Dive gear and Maintenance	$5,000	$304.59	$1,085.00	$1,651.00	$876.70	$562.46	$4,479.75	$520.25
Boat fuel and maintenance	$26,750	$683.06	$6,090.46	$3,256.69	$3,955.00	$163.09	$14,148.30	$12,601.70
Hummingbird Software	$1,200	$0.00	$1,200.00	$0.00	$0.00	$0.00	$1,200.00	$0.00
Lab Work	$10,000	$0.00	$3,192.66	$0.00	$0.00	$0.00	$3,192.66	$6,807.34
Permitting	$880	$656.62	$0.00	$0.00	$0.00	$0.00	$656.62	$223.38
Subtotal non-payroll	$59,146	$3,477.33	$14,487.12	$7,280.69	$5,418.74	$2,084.55	$32,748.43	$26,397.57
DMF Payroll Costs	$202,946	$45,226.00	$43,022.00	$37,993.00	$9,826.00	$4,903.86	$140,970.86	$61,975.14
Total	**$262,092**	**$48,703.33**	**$57,509.12**	**$45,273.69**	**$15,244.74**	**$6,988.41**	**$173,719.29**	**$88,372.71**

Acknowledgements

We appreciate all those who assisted in the field and reviewed this draft and budget, especially Mark Rousseau and Kevin Creighton of MA DMF and Aisling O'Shea and Elisabeth Cianciola of DFG.

Attachments

FIGURES #2-11

Tables #1-3

ATTACHMENTS

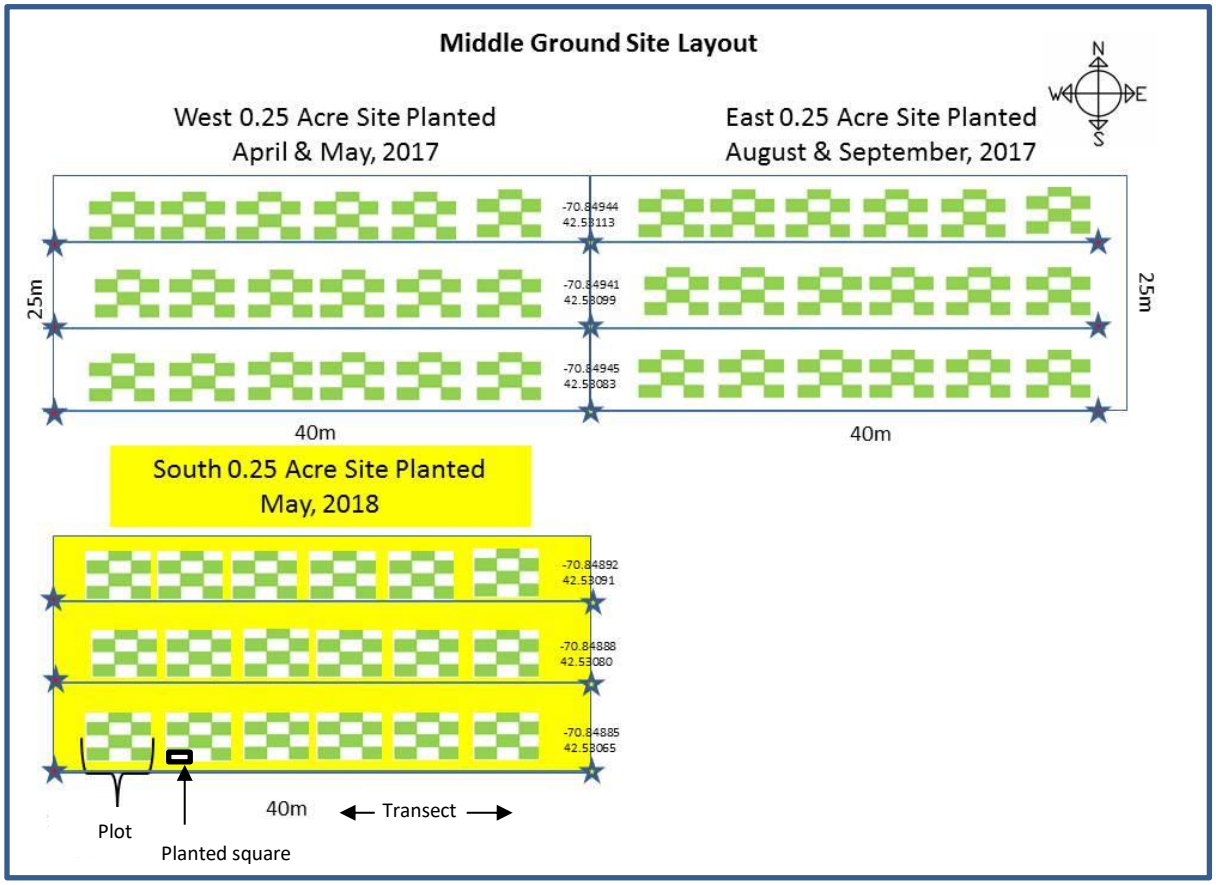

Figure 2: Middle Ground transplant site layout. Each **set** of three transects (formerly referred to as a site) spans approximately ¼ acre area. Middle Ground has three **sets** planted adjacent to each other for a total of 0.75 acre area. 18 **plots** each in a checkerboard pattern of 6 planted and unplanted 1 m^2 **squares** for a total of 5,400 shoots.

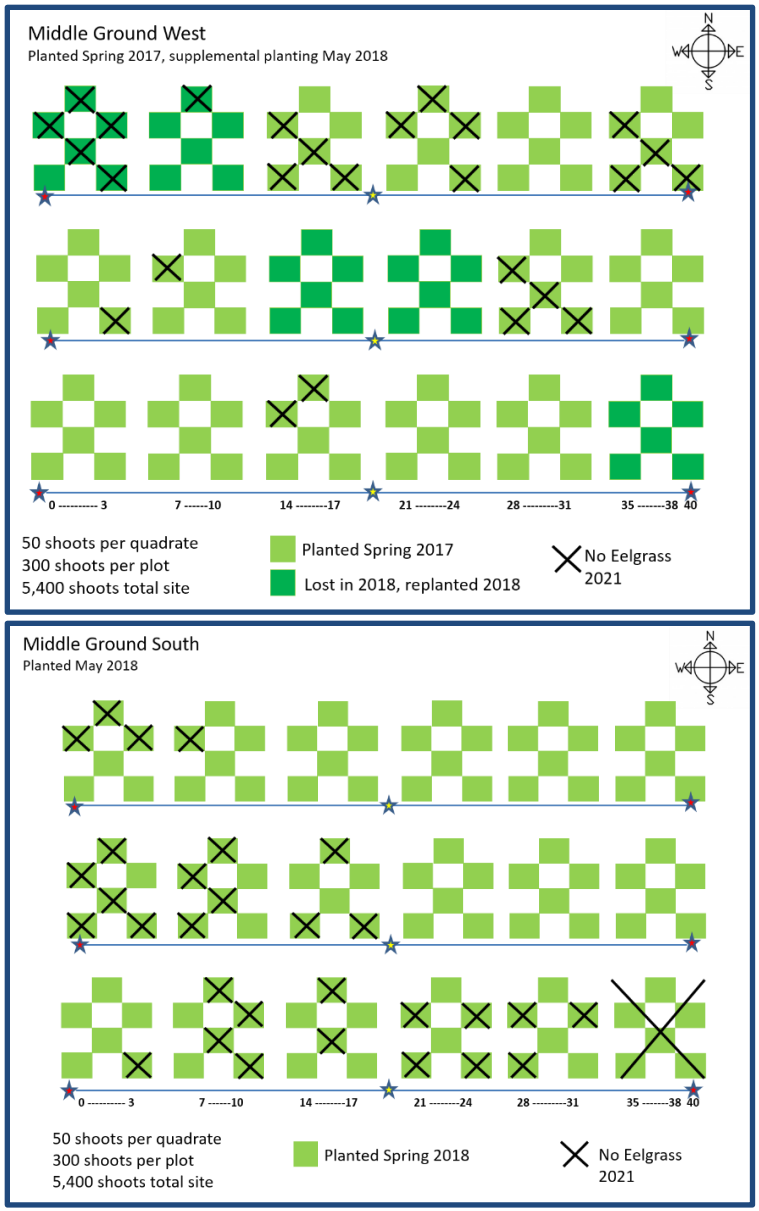

Figure 3: MGW and MGS 2021 square presence/absence. X = no eelgrass present in 2021.

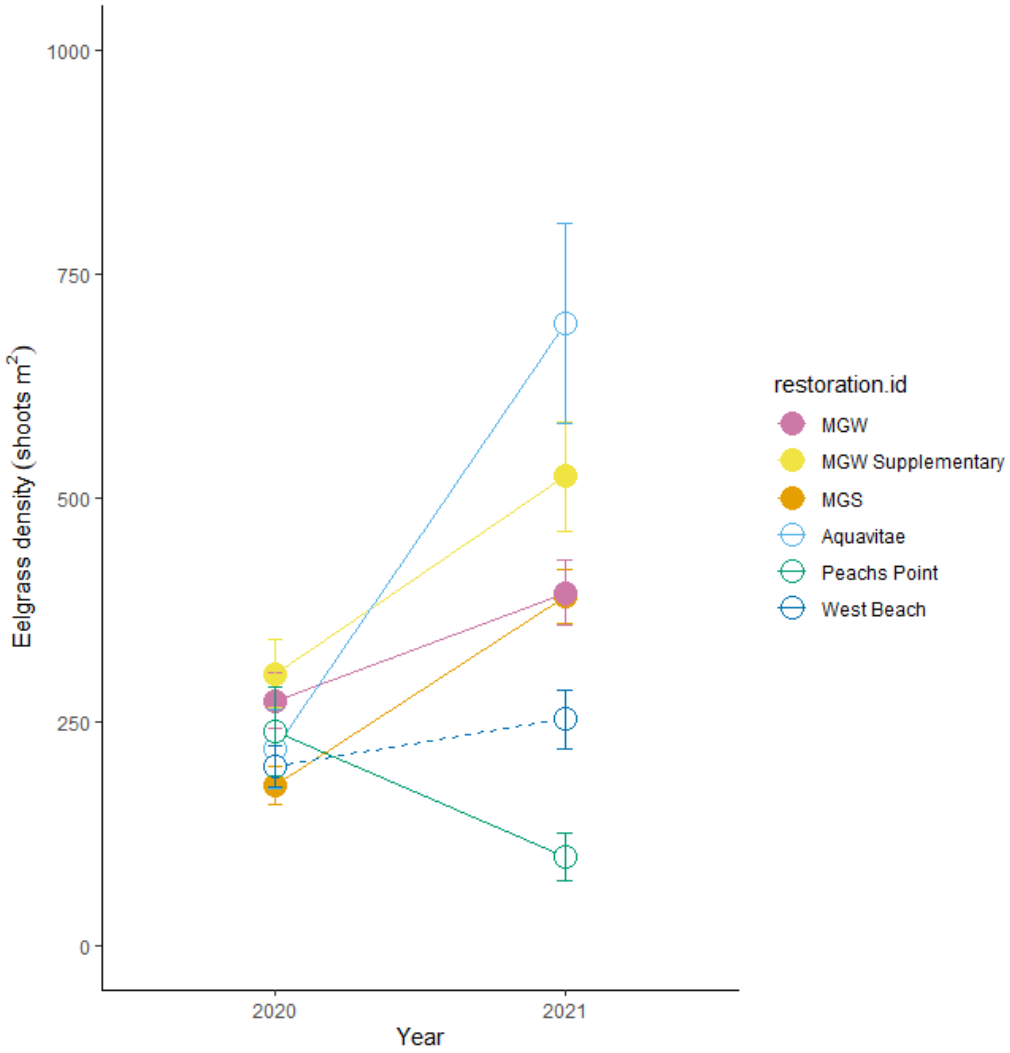

Figure 4. Eelgrass density across years (2020 vs. 2021) at transplant and reference sites. Transplant set means ± standard errors are represented by filled circles and error bars, and reference site means ± standard error are represented by open circles and error bars. Significant interannual trends within sites are represented by solid lines. Non-signficant interannual trends within sites are represented by dashed lines.

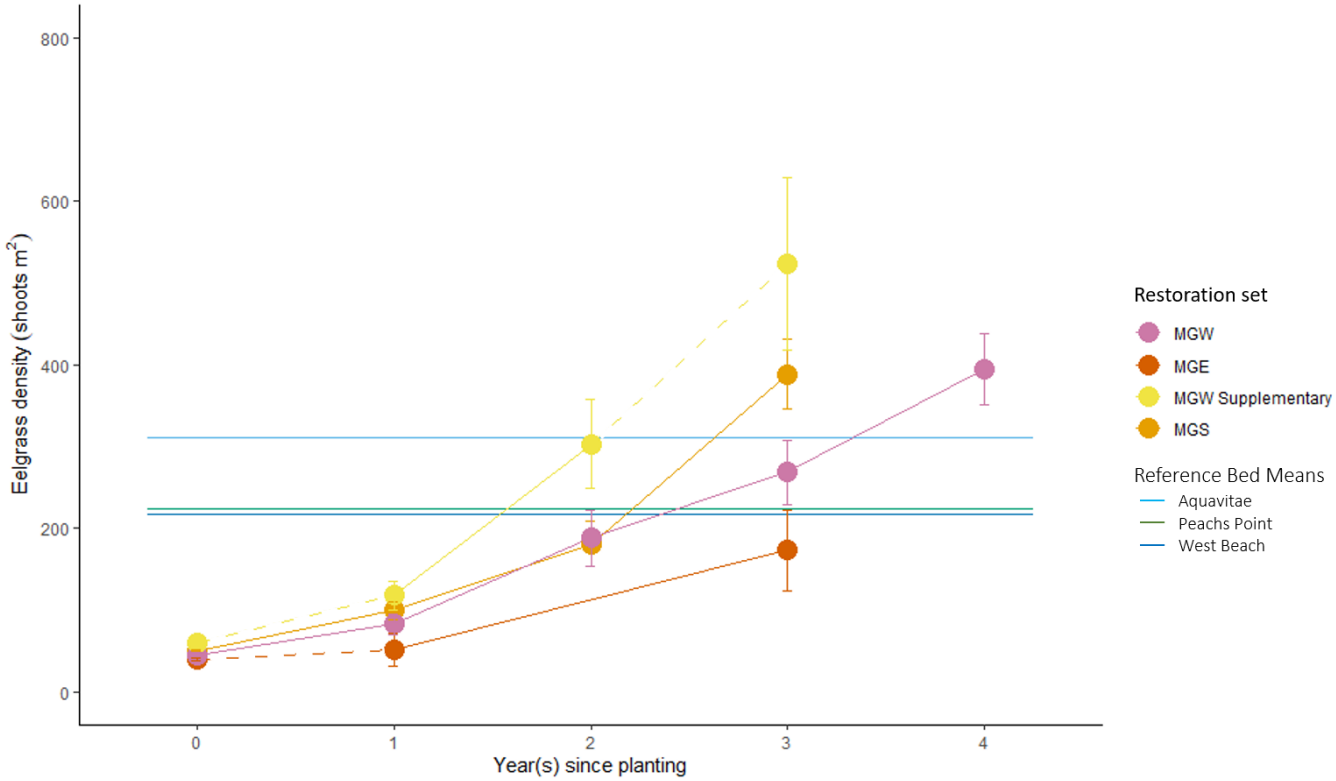

Figure 5. Eelgrass density across years since planting at transplant and reference sites. Transplant set means ± standard error are represented by circles and error bars, and reference site means are represented by horizontal lines. Significant interannual trends within sets are represented by solid lines and non-significant interannual trends within sets are represented by dashed lines (Benjamin Hochberg corrected pairwise paired t-tests, α = 0.05).

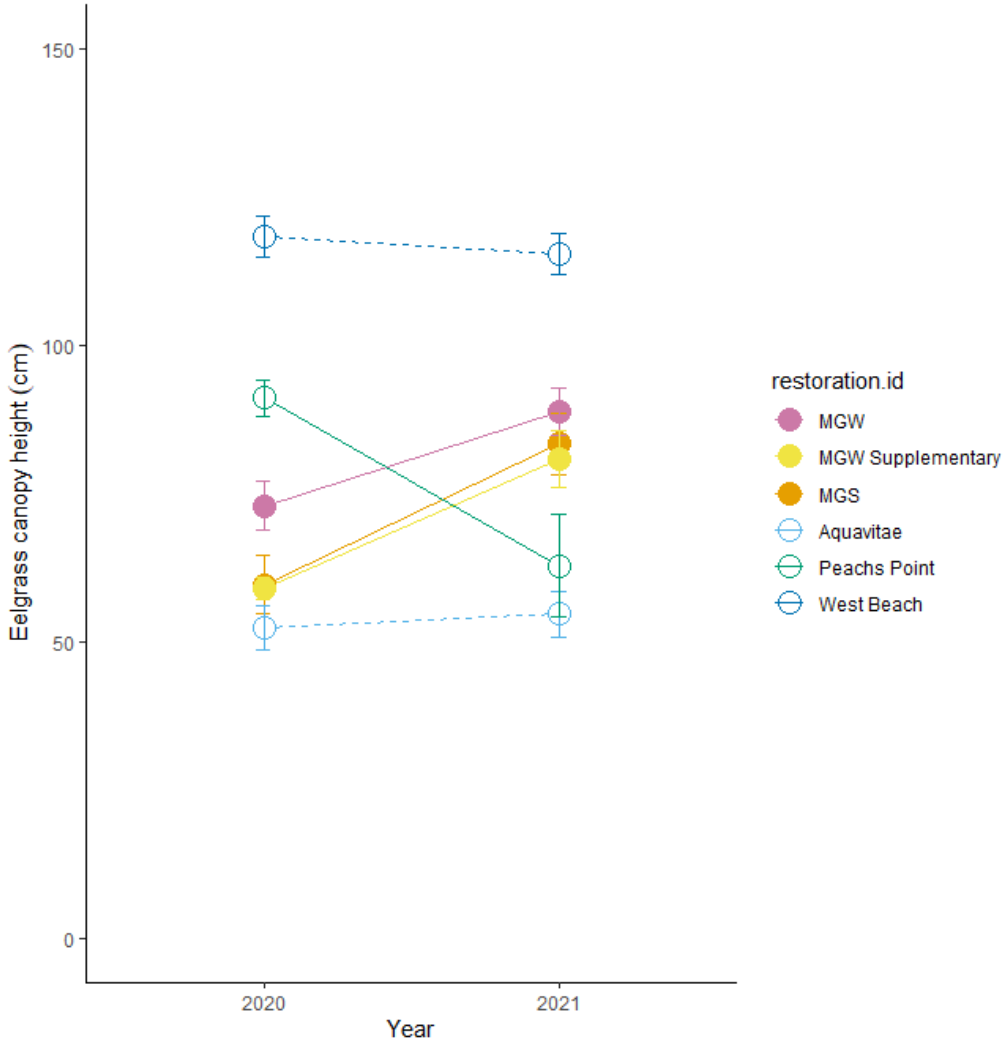

Figure 6. Eelgrass canopy height compared across years (2020 vs. 2021) at transplant and reference sites. Transplant sets ± standard errors are represented by filled circles and error bars, and reference site means ± standard errors are represented by open circles and error bars. Significant interannual trends within sites are represented by solid lines. Non-signficant interannual trends within sites are represented by dashed lines.

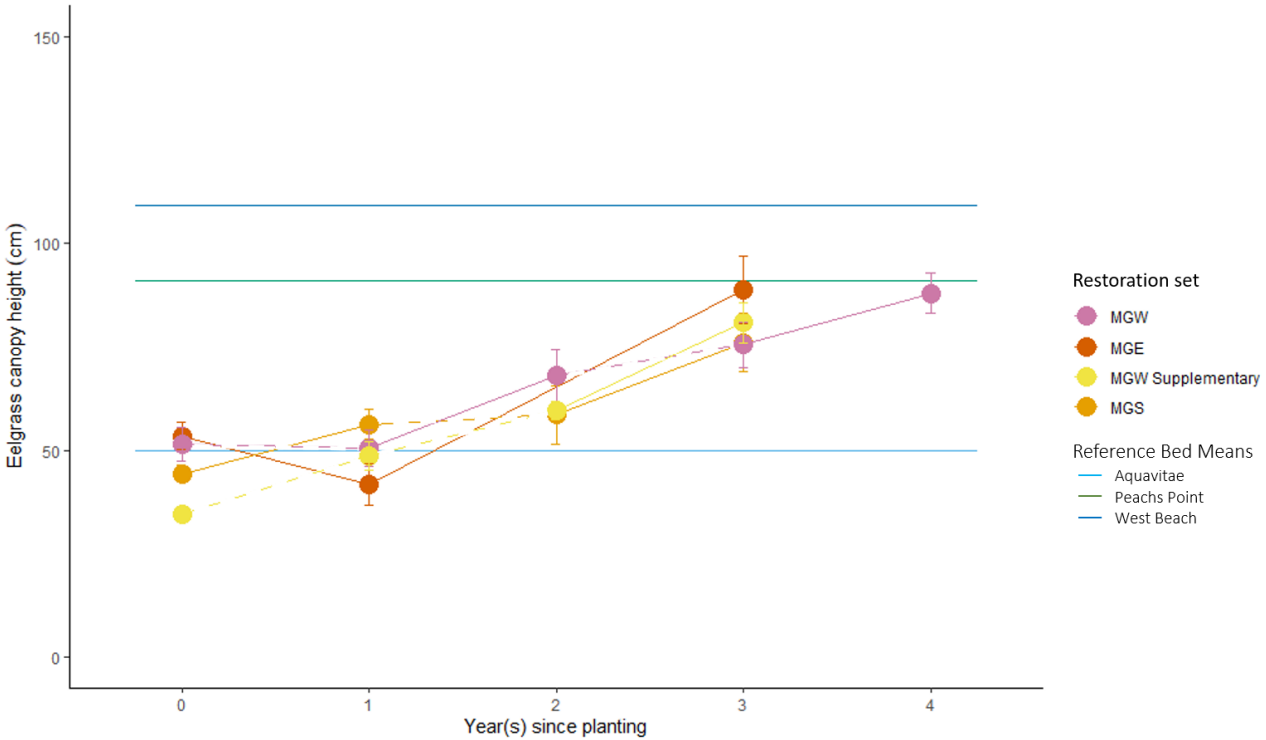

Figure 7. Eelgrass canopy height across years since planting at transplant and reference sites. Transplant set means ± standard error are represented by circles and error bars, and reference site means are represented by horizontal lines. Significant interannual trends within sets are represented by solid lines and non-significant interannual trends within sets are represented by dashed lines (Benjamin Hochberg corrected pairwise paired t-tests, α = 0.05).

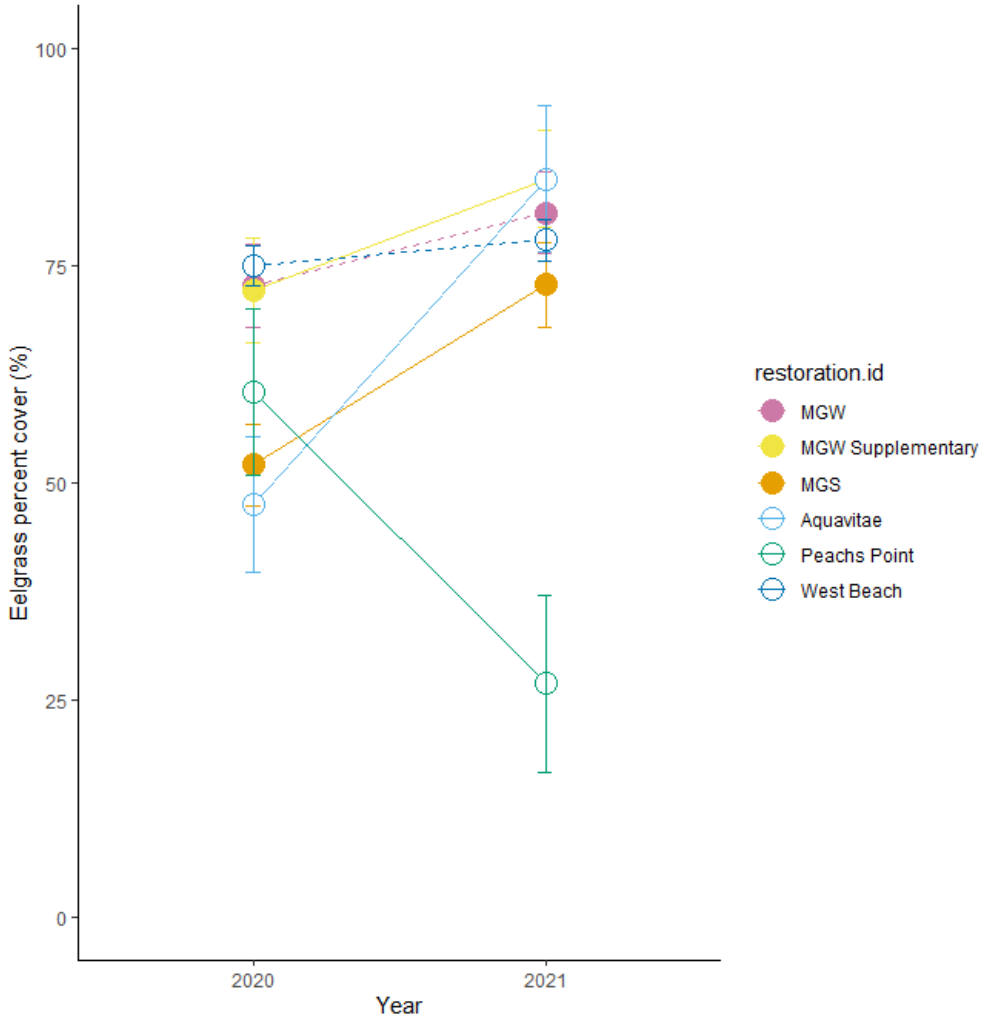

Figure 8. Eelgrass percent cover compared across years (2020 vs. 2021) and transplant and reference sites. Transplant sets ± standard errors are represented by filled circles and error bars, and reference sites site means ± standard errors are represented by open circles and error bars. Significant interannual trends within sites are represented by solid lines. Non-signficant interannual trends within sites are represented by dashed lines.

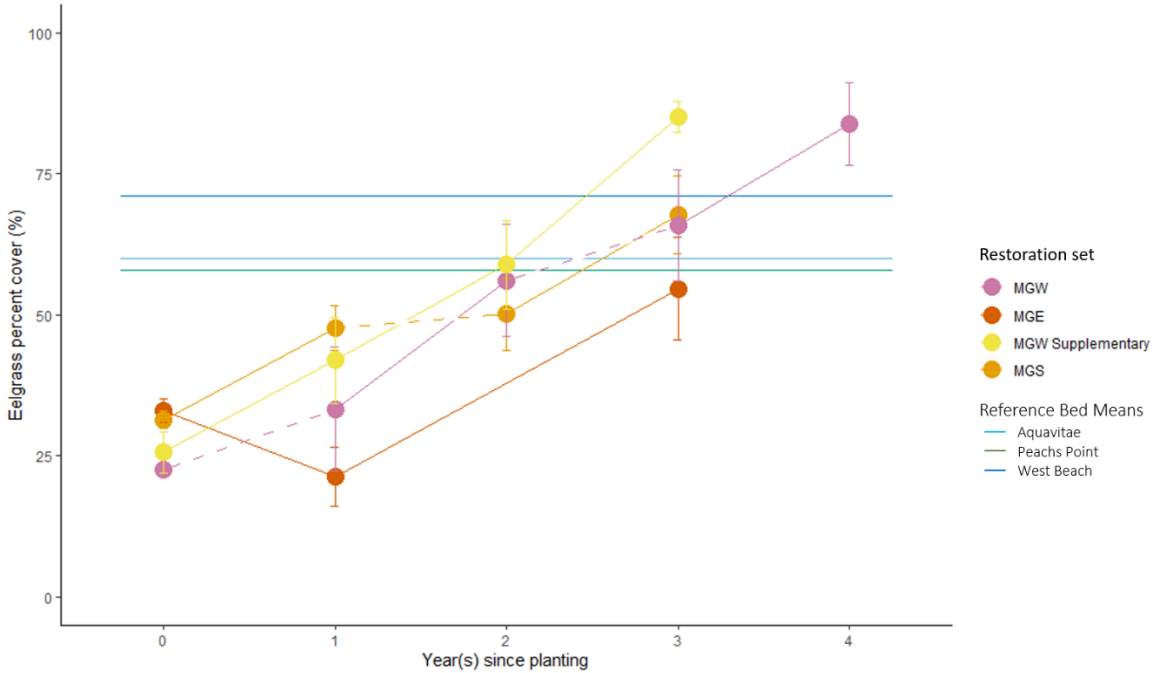

Figure 9. Eelgrass percent cover across years since planting at transplant and reference sites. Transplant set means ± standard error are represented by circles and error bars, and reference site means are represented by horizontal lines. Significant interannual trends within sets are represented by solid lines and non-significant interannual trends within sets are represented by dashed lines (Benjamin Hochberg corrected pairwise paired t-tests, $\alpha = 0.05$).

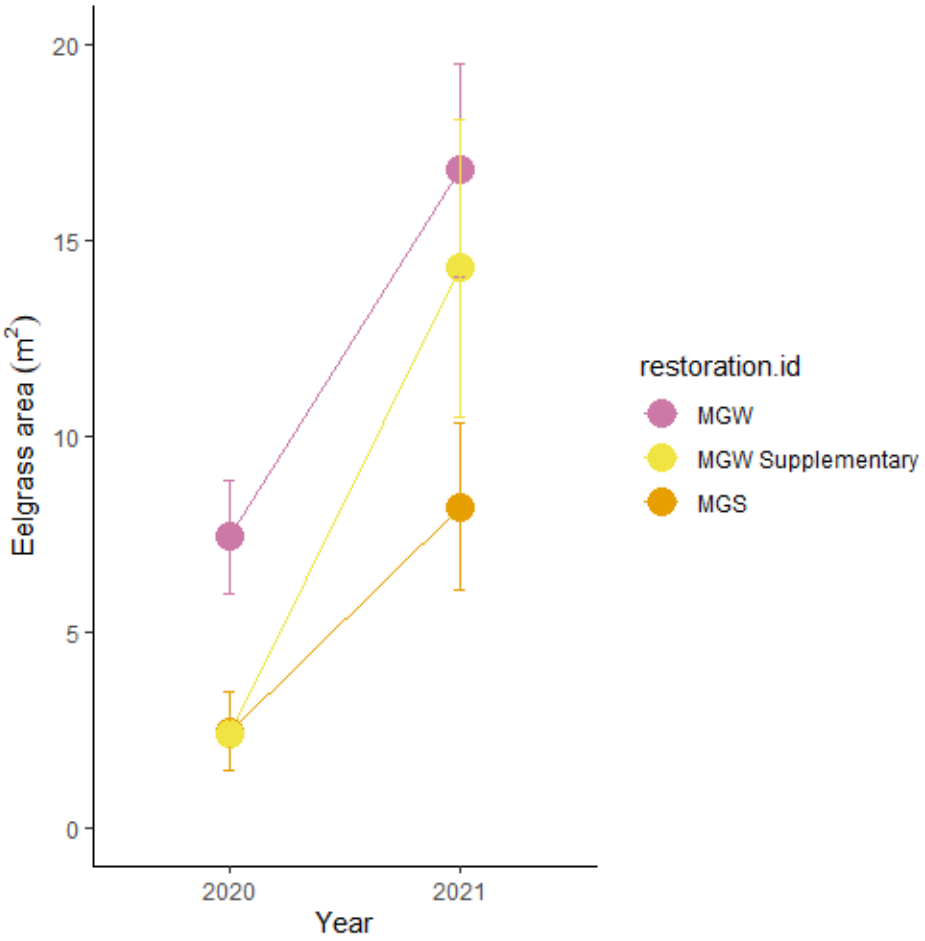

Figure 10. Eelgrass area compared across years (2020 vs. 2021) and transplant sets. Transplant set means ± standard errors are represented by filled circles and error bars. Significant interannual trends within sets are represented by solid lines. Non-signficant interannual trends within sets are represented by dashed lines.

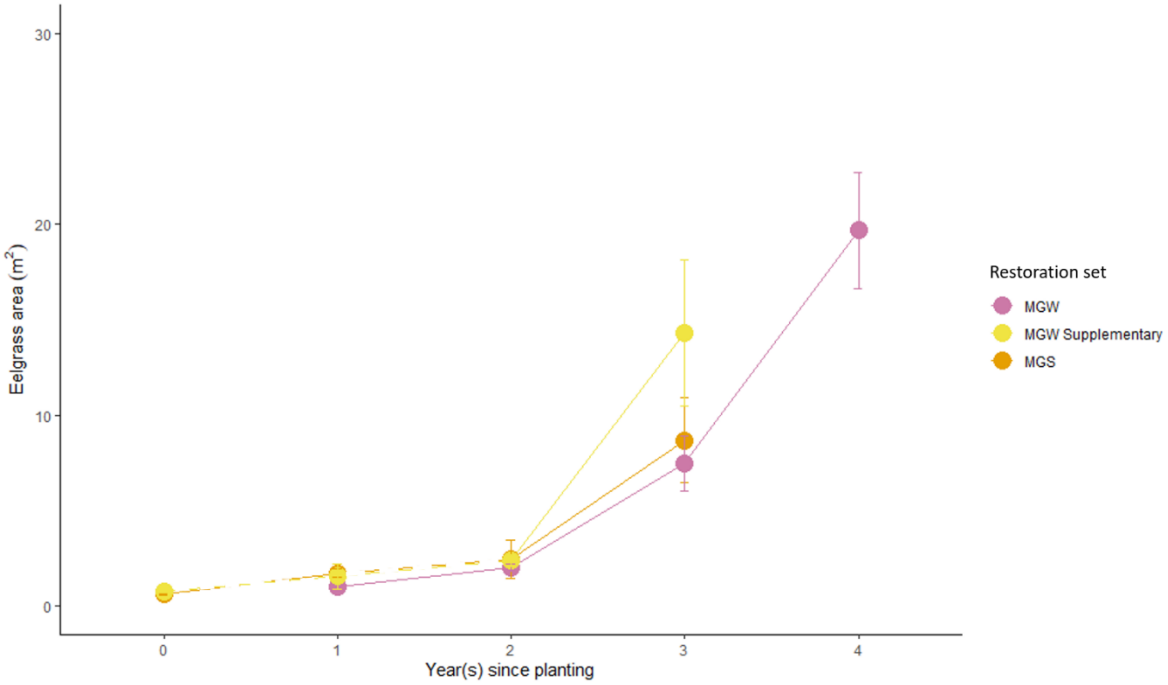

Figure 11. Eelgrass area compared across years since planting at transplant sets. Transplant set means ± standard error are represented by circles and error bars. Significant interannual trends within sets are represented by solid lines and non-significant interannual trends within sets are represented by dashed lines (Benjamini Hochberg corrected pairwise paired t-tests, α = 0.05).

Tables

Table 1: Planting Dates (1 plot=6 planted m^2 squares). Original sets were MGW and MGE. MGS and some plots in MGW are supplemental/ adaptive management shown in red.		
Event	**Date**	**Notes**
MGW mono	4/20/2017	2 plots planted
MGW Mono	5/4/2017	2 plots planted
MGW Mono	5/10/2017	2 plots planted
MGW Mono	5/12/2017	2 plots planted
MGW Mono	5/19/2017	2 plots planted
MGW Poly	5/24/2017	8 plots planted
MGE Mono	8/31/2017	10 plots planted
MGE Poly	9/7/2017	8 plots planted
MGW Mono	5/2/2018	4 plots planted
MGS Mono/Poly	5/10/2018	6 plots planted
MGS Mono/Poly	5/17/2018	6 plots planted
MGW Mono	5/23/2018	1 plot planted
MGS Mono/Poly	5/23/2018	6 plots planted
MGW seeding test plots	10/12/2018	1 seed plot planted

Table 2. Monitoring Dates. Dates in red represent anticipated monitoring events. Contract ends in 2022, with proposed extension to 2023 for monitoring of supplemental and replacement plantings.

Site	2017	2018	2019	2020	2021	2022	2023
MGW	June 12 (month 1) November 14 (month 6)	April 9 (post-storm) July 11 (year 1)	July 18 (year 2)	July 22 (year 3)	July 6 (year 4)	July (year 5)	July (year 6)
MGW (2018 supplemental)	NA	July 11 (month 1)	July 18 (year 1)	July 22 (year 2)	July 6 (year 3)	July (year 4)	July (year 5)
MGE	October 12 (month 1)	April 2 (post-storm) July 11 (year 1)	NA	July 28 (year 3)	NA	July (year 5)	July (year 6)
MGS (2018 replacement)	NA	June 14 (month 1)	July 10 (year 1)	July 16 (year 2)	July 7 (year 3)	July (year 4)	July (year 5)
West Beach	July 18	July 24	August 6	July 29	July 20	July	July
Peachs Point	August 9	July 03	July 24	July 7	June 28	July	July
Aquavitae	NA	July 03	July 24	July 7	June 28	July	July

Table 3. 2021 monitoring results. Means (Standard Error). (R) indicates reference bed.					
Site	**Planted Square Percent Survival (%)**	**Planted Square Density [shoots/m^2]**	**Planted Square Canopy Height (cm)**	**Planted Square Percent Cover (%)**	**Plot Area (m^2)**
MGW	73	394 (36)	89 (4)	81 (5)	16.8 (2.7)
MGW Supplemenatry	80	524 (61)	81 (5)	85 (6)	14.3 (3.8)
MGS	67	390 (30)	83 (5)	73 (5)	8.2 (2.1)
MGE	NA	NA	NA	NA	NA
Peachs Point (R)	NA	100 (27)	63 (9)	27 (10)	NA
West Beach (R)	NA	253 (33)	115 (3)	78 (2)	NA
Aquavitae (R)	NA	695 (112)	55 (4)	85 (8)	NA